
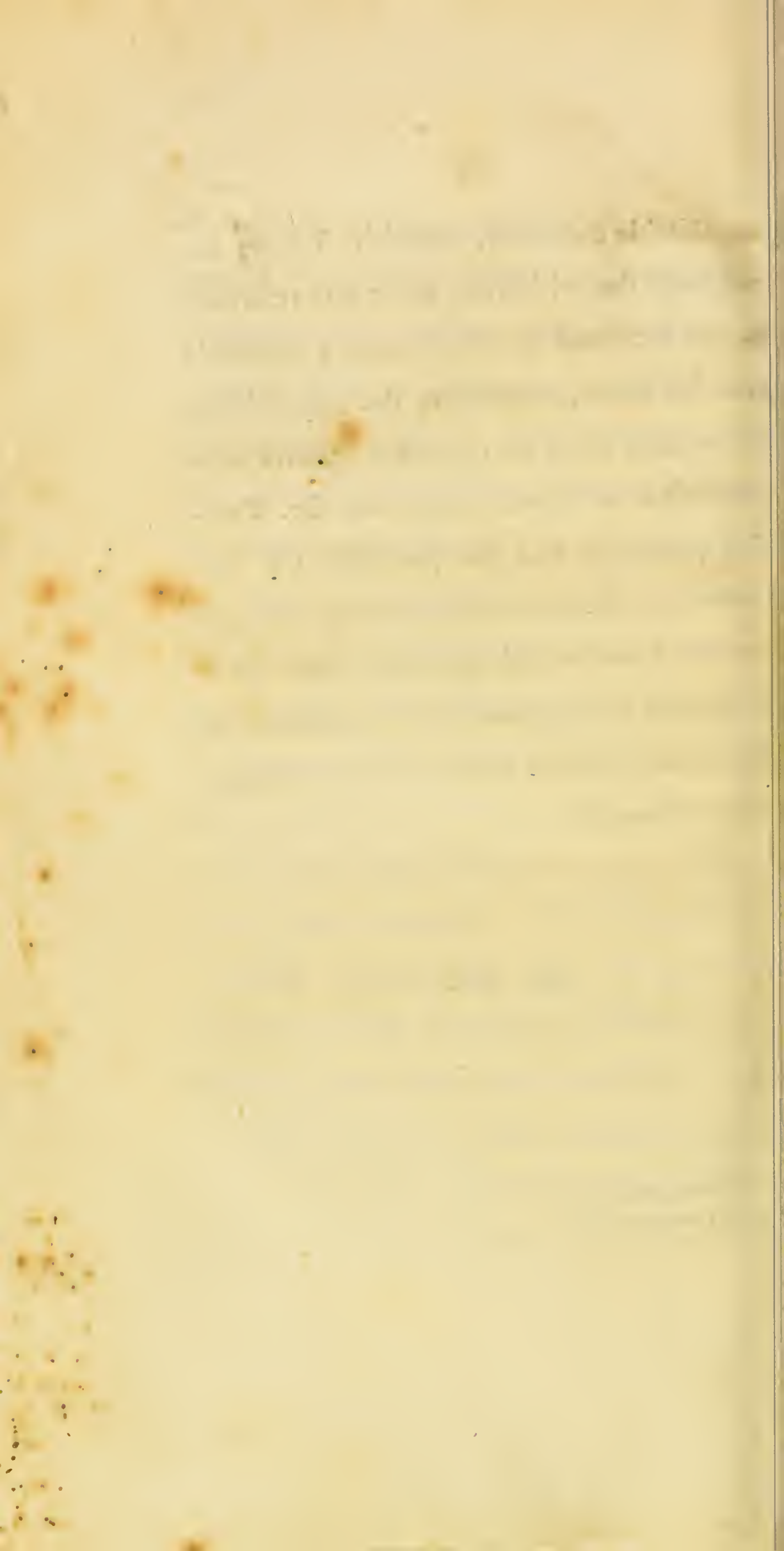


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ERRATA.

Page 6, line 10, dele *is*.

Page 10, line 6 of the note, for *nitric gas* read *nitrous gas*.

Page 11, line last, for *hot* read *not*.

Page 19, line last but one, for *de Connoissances* read *des Connaissances*.



A
PROPOSAL

FOR

DESTROYING

THE

FIRE AND CHOAK-DAMPS

OF

Coal-Mines;

AND

THEIR PRODUCTION EXPLAINED

ON THE

PRINCIPLES OF MODERN CHEMISTRY:

ADDRESSED TO THE

OWNERS AND AGENTS OF COAL-WORKS, &c.

BY THOMAS TROTTER, M.D.

LATE PHYSICIAN TO HIS MAJESTY'S FLEET,

&c. &c. &c.

NEWCASTLE:

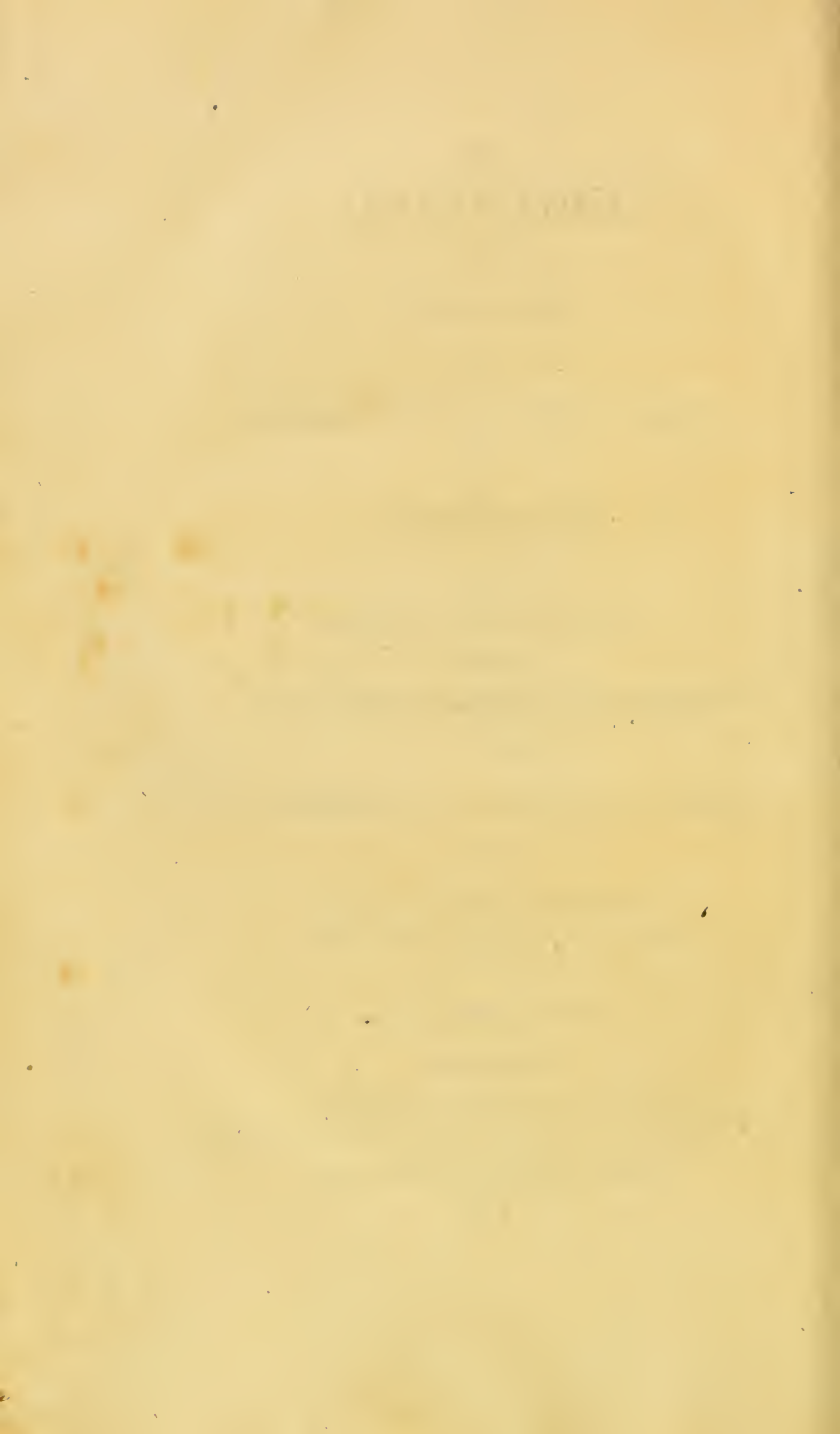
PRINTED AND SOLD BY J. MITCHELL;

Sold also by all the other Bookfellers in Newcastle, Shields, Sunderland, and

Durham; and by

LONGMAN, HURST, REES, AND ORME, LONDON.

1805.



TO THE
OWNERS AND AGENTS
OF
COAL MINES

IN THE
COUNTIES OF NORTHUMBERLAND, DURHAM,
&c. &c.

Gentlemen,

I have herewith the pleasure of presenting you with a proposal for destroying, by chemical agents, those noxious gases, “fire and choak damp,” that on numerous occasions have proved fatal to many of your workmen. The subject, I think, admits of demonstration, at least as far as human knowledge can depend on the faith of experiment. I have not attempted to puzzle a plain understanding by offering conjectures instead of truths, or to bewilder common sense by specious, but fanciful theories. Though a physician, my doctrine is intelligible, and my practice humble. No merit is claimed, where there is no invention; and no fame is expected

for being industrious. If I appear obscure sometimes, it is from making brevity my aim. I only hold out a short explanation of well-known facts, in the hope of seeing them conducive to save human lives, whose labours are useful to the community.

Philosophy can little avail society, if confined to the study or the laboratory: it is valuable only as it makes mankind comfortable and happy. This little essay may be considered as the continuation of some former labours in the public service. To the cause which I have espoused you will not find me a cold advocate; but I shall be highly honored by receiving your approbation.

I am, with great respect,

Gentlemen,

Your faithful humble servant,

T. TROTTER.

Northumberland-Street,

Oct. 14th, 1805.

A
PROPOSAL
FOR
DESTROYING THE FIRE AND CHOAK DAMPS
OF
COAL-MINES.

SINCE my residence in this neighbourhood, a number of accidents have happened among pitmen, employed in coal-mines, by explosions of what is called *fire-damp*, the hydrogenous gas of modern chemists, and very lately thirty-two men have been killed in Hebburn main. Suffocation from *choak-damp*, the carbonic acid gas of chemists, has also frequently happened. As far as my enquiries go, no certain means have yet been devised for preventing those fatal accidents. The effect of ventilation from the shaft cannot be perfect, at so great a depth below ground as one hundred fathoms. This appears to me of vast importance in a *mining district*; and the preservation of so many

valuable lives must at all times interest the humane owners of these extensive works.

On considering this subject, I was immediately struck with the great analogy it has to the ventilation and purification of ships. In the third volume of my work on the Diseases of the Fleet, published since I fixed in Newcastle, a chapter is devoted to that branch of naval discipline, as connected with the preservation of life, and the prevention of disease in his Majesty's naval service. With these preliminary studies, I was in some measure prepared for this investigation.

It has been one of the happy consequences of the modern improvements in chemical science, to explain numbers of facts, in the different arts, which, though familiar to us before in their general result, yet we knew nothing of them in principle. In nothing is this better exemplified than in *Pneumatology*, or the doctrine of airs. This, indeed, from the lately

acquired knowledge and rapid discoveries, may be justly called of itself a new science. We can turn our eyes into no part of nature, without being edified and amused by pneumatic chemistry. The sky, the lake, and the cavern, are its vast laboratories. The invisible atmosphere which surrounds us, and of which we breathe, is a *mixture* of different airs. Water, in all its forms, is a compound of hydrogenous and oxygenous radicals. Every animal and plant can be resolved into numerous gases; and the solid remnant of both is triflingly small, when compared with the aerial products. Even *minerals*, such as stones and metals themselves, hold in combination different portions of elastic fluids; some of which, when disengaged, leave the stone in a state of causticity, as in quick lime; and others, being added to metals, oxydate them, and give them their medicinal or poisonous qualities, according to the quantity combined. Some of these

airs are the *pabulum*, or support of life; others destroy it, and have received the name of *azotic*. Such are the enchanting views this subject opens to the mind of the philosopher! Such is the utility which it brings with it to the arts which cherish and embellish life!

The generation of hydrogenous gas, or, as it is otherwise named, inflammable air or *fire-damp*, in coal-mines, is rendered familiar to us by modern chemistry. The decomposition of water, into two kinds of air, accounts satisfactorily for their production: the fine experiments of LAVOISIER on this subject are decisive. The first and second experiments of that celebrated philosopher, to be found in chapter viii. page 83, of his Elements of Chemistry, are an epitome of that process of nature which is continually going on when *carbonaceous* matter, or *coal*, comes in contact with *water*, and is suffered to stagnate. The consequence must be the decomposition of the moisture; the light

hydrogenous gas, or *fire-damp*, flies off, or ascends, from its specific gravity being so much less than atmospheric air, as 13 to 1, or 16 to 1, if perfectly pure; and the more ponderous carbonic acid gas, or *choak-damp*, from being of greater specific gravity than common air, falls to the bottom. It is *caloric*, or the matter of heat, which enters their composition, and preserves them in the state of permanent elastic fluids. The base or radical of the hydrogenous gas, or *fire-damp*, is a simple element: but the carbonic acid gas, or *choak-damp*, is found to be composed of *carbon and oxygen*; the first it receives from the coal, and the latter, being a constituent part of water, from the water it receives it: they are in the proportion of 0.26 of carbon, to 0.74 of oxygen.

This is the simplest method of accounting for the production of these airs; and wherever ventilation is imperfect, it is plain that they must accumulate in great quantities. All

corners and crevices, where a current of wind cannot be directed in full force from the shaft, must be speedily occupied by the noxious gases. It appears, in the late disaster at Hebburn colliery, that a door was opened by a man carrying a light in his hand, which door led to an apartment filled with *fire-damp*, which immediately burst into flame, and exploded.

The analogy between a ship's hold and a coal-mine, in the production of these noxious gases, is thus to be explained:—The hold of a ship, like the mine, is close and warm; the water in the well, what may leak out of casks, or what may fall from the decks, coming into contact with the timbers, soon stagnates, emits a fetid smell which flies upwards, diffuses itself over the decks, and wherever it comes near white paint, tarnishes it, turns it black by decomposing the metallic oxyde, or calx of lead, of which white paint is made. This fetid substance is called the *bilge vapour*, be-

cause it rises from the water in a state of putrefaction. Now while this volatile gas ascends from its levity, and is perceived by its smell in the decks; another gas, with very different qualities, is generated at the same time. The oxygen disengaged, which is another constituent part of water, is attracted by the carbonaceous principle of the wood, and thus forms carbonic acid gas; and from being very heavy, it falls to the bottom; and often floats on the surface of the well, till it accumulates in such quantity, that in foul ships the carpenters have frequently been suffocated in descending to let in fresh water to sweeten the hold. The first of these airs is the hydrogenous gas of modern chemists, or the *fire-damp* of mines: the other, is the carbonic acid gas of the chemists, and the *choak-damp* of mines. But while this decomposition of moisture is going on in the ship, there is this difference from the coal-mine, that the hold being much more ex-

posed to the influence of ventilation, the *fire-damp* can never be accumulated in such quantity as to be in danger of combustion, for it flies off as it is formed. Seamen are familiar with this kind of air in long voyages: when the water becomes putrid in the casks, they amuse themselves by taking out the bung and setting it on fire. The water of the Thames is more liable than any other river water to undergo this change; which is owing to the animal and vegetable filth that mix with it, and facilitates the decomposition: but when this gas is once dispelled, the Thames water is said to keep better than the others.

We also see in ships, as it must likewise happen in coal-mines, that different substances of a vegetable nature, but particularly sugar or molasses, beer or spirits, leaking from casks, greatly promote the decomposition of the moisture, and cause a quicker generation of the foul vapours. Salt-water thus becomes sooner

putrid than river water: and when a cask of spirits happens to leak into the hold, the efflu-
vium is extremely fetid, from the large propor-
tion of hydrogenous gas that is evolved. Hy-
drogen is known to be a constituent of
alcohol, or ardent spirit, and therefore it is dis-
engaged in prodigious quantities at that time;
and there is sometimes a necessity for drench-
ing the hold all over, to get quit of the feter.
This is the gas that gives the breath of the
dram-drinker its suffocating smell. If, there-
fore, any substance of a vegetable or animal
nature, is allowed to mix with any stagnant
water in a mine, foul air will be more quickly
produced. This shows the necessity for the
utmost cleanliness in a pit. The provender
and soil of the horses kept below, may have
considerable effect in this way, and ought to be
carefully swept up and sent above ground.—
Such is the simple explanation of one of the
sublimest operations in physics.

These noxious gases, "*fire and choak damps*," I believe, are almost peculiar to the coal-mine. It does not appear that any like accidents happen to the workmen in tin and copper and lead-mines, as have been lately known in this neighbourhood: but even in these, if water were allowed to stagnate, and vegetable or animal matter thrown into it, it would soon pass into the state of putrefaction and decomposition, and yield up the noxious gases, till they would accumulate in such a manner as to produce all the dangerous effects which are observed in collieries.

That this condition is peculiar to coal-mines may be accounted for from the nature of pit-coal and its chemical analysis. The origin and formation of this bitumen, are subjects on which naturalists are not yet agreed; some contending for its being formed of animal matter, and others that it is of vegetable offspring. It probably consists of both, which is rather to

be inferred from its analysis. To the oil which is found in coal, it owes its combustibility: it first softens, is in a manner half melted, and then burns. When this oil is partly consumed, the coal is in the state of coak; enough remains for continuing the combustion, but not so much as to be dissipated in a black smoke forming foot. By heat, this bitumen, in a close vessel, and a distillatory apparatus, affords an alkaline phlegm, concrete ammoniacal carbonate, and an oil, which, as the distillation proceeds, takes a deeper colour and becomes more ponderous. There passes at the same time a large quantity of elastic inflammable fluid, which is commonly thought to be oil in vapour, but is properly hydrogenous gas mixed with azotic gas, with carbonaceous matter dissolved in it, and with carbonic acid gas.* There remains in the retort a scorified carbonaceous matter, which is susceptible of combus-

* Fourcroy.

tion, and is what we call *coak*. This coak comes near to the nature of vegetable coal, and is then more fit for many purposes of the arts.

Now, in this chemical history of *coal*, we find all the ingredients which account for the formation of the two noxious airs of which we professedly treat. These airs or gases, being diffused in the mine, and accumulating in those places less liable to be disturbed or agitated by a current of wind from above, become now objects for new combinations, or in their present state destructive to animal life.

WATER, that forms so important a part in the operations of nature, as to have been considered an universal solvent and a homogenous body, has, by modern chemistry, been at once deprived of its rank as an elementary substance. LAVOISIER, famous in the annals of science, by his talents and his fate, in April 1784, performed the celebrated experiment that proved water to be a compound body, con-

fisting of the oxygenous principle and the base of inflammable gas. This fact is now universally admitted, and it explains many phænomena in nature, till then unknown. The proportion of hydrogen is as 0.15 to 0.85 of oxygen; hence the former derives its name. It has been further proved, whenever hydrogen is burned with vital air, water is produced. Thus pitmen, who have been scorched with the explosions of *fire-damp*, appear as if drenched with water, which is a nice example of the fact.

In artificial experiments, in order to decompose water by iron, zinc, charcoal, or oil, as frequently done by chemists, it would seem that a great degree of heat is necessary: but in the coal-mine and hold of a ship, or even in marshes and stagnant pools, the hand of nature effects it by the common temperature of the atmosphere. These articles, according to the language of chemistry, are said to have a

stronger attraction for oxygen, than oxygen has for hydrogen; they therefore cause a separation of them, which is the decomposition of moisture. Water is preserved fluid by *caloric*, or the matter of heat with which it is combined, and when this heat is given out it freezes.

Water in a pure state, as when it is distilled, if put into glass vessels, or others not capable of acting on it, and closed by stoppers, or *hermetically sealed*, would remain sweet as long as the vessels lasted. In this manner it was shown by a professor to his pupils, after being kept 50 years. But if you put water into a wooden vessel or cask, particularly a new one, it soon spoils, and yields *fire-damp*, which gives it a disagreeable taste, and the smell of rotten eggs. The new chemistry suggested to me, in the summer of 1792, that casks might be seasoned, so as to keep water sweet for long voyages; and, after many trials, I found that

the best practical method was to *char* the surface of the casks, in putting them together by the coopers, both heads and staves. Thus the whole surface being already in a state of combination with oxygen, did not act on the water with such rapidity, and it remained pure and sweet for nineteen months. This is now the method of preparing casks in the navy.*

The *fire-damp* of mines, from its burning with vehemence, when in contact with atmospheric air, and from having been the subject of experiment, is known to be the same with the hydrogenous gas of modern chemists. Dr. Priestly first collected it, and found it to be a permanently elastic fluid, and named it *inflammable air*. When animals attempt to inhale it, they either become convulsed, or instantly die. It is commonly perceptible by its fetid smell; and its disposition is to take fire when it comes near flame, or by passing

* See the Author's Medical and Chemical Essays, 2d edition, Jordan, London.

through it the electric spark. It has lately become famous by filling balloons—an invention which belongs to the late Dr. BLACK, professor of chemistry in Edinburgh. It is only produced where there is water, as in mines or pools putrefying with animal and vegetable matter. From pools, marshes, and stagnant lakes, it has been collected by inverting over them close vessels. It is said to be the cause of meteors in the atmosphere, where it ascends; and on being fired by the electric shock, it gives the report of thunder, is then converted into water, and falls to the earth in heavy torrents called thunder showers. Hydrogenous gas has the property of *dissolving and suspending in it*, carbon or charcoal, sulphur, phosphorus, and the substance called azote. These are the articles most apt to alter its purity; and in proportion to the quantity of them, its perfect combustibility depends. They also modify the smell, and render it in some-

situations insufferably fetid. But in the coal-mines of this district, it is probably generated in great purity, as is proved by its compleat inflammability and sudden explosion. Such is an epitome of the chemical properties of *fire-damp*.

The *choak-damp* of coal-mines is the fixed air of Dr. BLACK, the mephitic acid of MORVEAU, the mephitic gas of MACQUER, the aërial acid of BERGMAN, and the cretaceous acid of BUEQUET. Its discovery has immortalized the name of BLACK, as from it we are to date the superstructure of Pneumatic Chemistry. On being first known, it was called fixed air, as the supposed bond of union in bodies: mephitic acid and gas, as being fatal to life, and having the properties of an acid: aërial acid, because it is met with in the atmosphere: cretaceous acid, because found in chalk: and lastly, it has been named carbonic acid gas, from being composed of charcoal and oxygen,

the acidifying principle. When expelled by heat from chalk, or marble, it leaves them in the state of quick lime; and in the state of mortar, attracts the gas again from the atmosphere, which gives firmness to the wall. It renders all the alkalis mild. It is evolved in great quantity during fermentation, by which cellars are sometimes rendered uninhabitable: it is produced in the act of respiration of animals, and in the decomposition of all animal and vegetable matter. It is the vapour which kills animals in the Grotto del Cane in Italy; it exists in the holds of ships, in caverns, and old wells; it dissolves iron in water, and gives to the latter an acidulous taste. It is more than double the weight of atmospheric air. It contains 28 of charcoal to 72 of oxygen.

Charcoal is one of those bodies that has the strongest attraction for oxygen, which accounts for the very frequent composition and large production of carbonic acid gas, or *choak-damp*.

We thus observe, from the brief history given of water, and its resolution into hydrogen and oxygen, how familiar this department of experimental philosophy has rendered the generation and formation of the noxious damps of mines: and it so happens, that the two gases must always be produced at the same time, which ought to excite great caution in all who are employed in these deep recesses, so distant from a free ventilation.

With this preliminary knowledge, we are now enabled to turn our attention to such prophylactic measures as may be necessary for securing the workmen.

The purification of a coal-mine considerably differs from the same intention in a ship, an hospital, or jail, from its disadvantageous situation. I might swell this essay to a great bulk, were I to digress into these subjects, or to contrast all that has been said or written. Even this neighbourhood has lately heard contagion

discussed in a new style, without much edification. To be a little methodical, I shall, in the

1st place, speak of preventing the formation of these airs in the mine; and in the

2d place, the means to be adopted for removing them after they are formed.

1st, *To prevent the formation of fire and choak-damps.*

The deeper the mine, the more winding and tortuous its area; and the more frequent its pillars of support to the superincumbent strata, it is evident the air below will be more speedily adulterated, and less within the sphere of perfect perfusion. But it would appear that one of the great objects in this business must be to prevent the stagnation of the water, for where there is no moisture, there can be no generation of the foul airs. The mine that has the most copious flow of water into it, must have the best

chance of being the most pure, as being in less danger of its putrefaction: and wherever water is in danger of stagnating and giving out vapour, it ought to be a piece of duty strictly attended to, to direct a stream of pure water at short intervals into these places, so as to dilute and sweeten the whole, that they may be pumped out. Such places will be increased in their natural tendency to putrefaction, should pieces of timber, chips of wood, or the foil of horses, &c. as formerly mentioned, be allowed to mix in the water. The temperature of a deep mine is much the same in winter as in summer, being unaffected by the sun; but it ought to be known, that increased heat greatly favors the separation of the constituent principles of the water, and facilitates the new combinations. A number of lights, and the pitmen heated with work, will soon heat a small space so as to exemplify this fact.

To keep a coal-mine clean, and free from extraneous matter, and to take especial care that no water is suffered to stagnate, must, therefore, be indispensable duties. And if these are practicable, the formation of foul air must either be small, or entirely prevented. To throw the water out of the mine is the business of mechanics.

2dly, *The means to be adopted after the fire and choak-damps are formed.*

From the short history which has been given of the properties of these airs, it is obvious that they have very different qualities. The *fire-damp*, or hydrogenous gas, when in its utmost purity, is 16 times lighter than atmospheric air; while the *choak-damp*, or carbonic acid gas, is double the weight of common air. Agreeably, therefore, to a general law in hydrostatics, the lightest permanently elastic fluid will rise to the roof of the mine, while the more ponderous will sink to the ground. If

these airs do not by their bulk fill the space between the floor and the top of the mine, a stratum of atmospheric air will lie between them, as being neither so heavy as the *choak-damp*, nor so light as the *fire-damp*. Indeed wherever the latter takes fire, it must be from being in contact with atmospheric air, as it cannot be inflamed without it.

As one of the characters of the *fire-damp*, I have mentioned its fetid smell. It cannot be lodged or accumulated in any quantity, without being detected by an unpleasant impression on the olfactory organs. It is also fatal to animal life; though, perhaps, it is seldom in so concentrated a state in nature, as to prove fatal to animals by respiration; but even in mines it may have the effect of causing oppression of the breast and a difficulty of breathing. When a person feels these effects, he ought to retreat instantly. I am ignorant of the workmen having any familiar method of their own

for detecting its presence, beyond what is just said.

If any person carrying a light in his hand, unexpectedly sets fire to a column or mass of *fire-damp*, he ought instantly to lie down with his face flat on the ground. If safety is to be found, it must be in this posture, as the gas is known to be thickest at the roof of the pit, and consequently there it must explode with a fiercer flame. All other persons near, and observing this, ought to fall down in the same manner, and to creep, not walk, to a place of safety, if such can be obtained.

While the moral world has been convulsed and agitated by the revolutionary spirit which has been engendered in France for the last sixteen years, the natural history of man has also, during that period, been marked by disaster. Fevers of the most fatal kind have almost depopulated whole cities and districts of Europe and America. The West Indies have

been the grave of numerous armies sent from Great Britain, by an epidemic disease. The southern provinces of North America have been frequently visited by this scourge. A pestilence has thrice raged in Spain, and extended once to the garrison of Gibraltar. While the thrones and altars of Italy were robbed and pillaged by a military banditti from France, many of the towns and states were victims of contagion. The ships and regiments of this country on home service, as well as those of France, have in their turn been infested by dangerous fevers; and in Egypt, some of the troops of both countries have been cut off by the real plague. Numerous, therefore, have been the theories offered on these prevailing diseases; and equally numerous the projectors who have appeared with *balm* in their hands, to prevent or heal the wounds of suffering humanity.

Epidemic fevers had long ago been supposed to owe their origin to some quality or constitution of the air ; and more lately, from the exhalations of the sick extending the disease to others, the cause has been modified in name into contagion. Acid fumes, in particular such as vinegar and sulphur, were then employed as correctors of the atmosphere; and the present times have added the nitrous and muriatic acid vapours. The first is the acid of salt-petre; the latter that of common salt. In the fleet, the fine discipline of the officers, which included the speedy separation of the infected, pure ventilation, and cleanliness in person, clothing and lodging, were found all that was required. In the course of nine years, 150 ships, under different degrees of infection, were successfully cleared, without ever one of the number going into harbour to take the stores out. I am under the necessity of mentioning these circumstances, because I am about

to recommend to the coal-mines what I opposed in ships and hospitals.

The nitrous fumes being much inferior in power, and less volatile and expansile, than those of the muriatic acid, for arresting and subduing hydrogenous gas, I shall not touch upon them here. The latter, though first used by an English physician, the late Dr. JOHNSTONE, in a fever raging at Kidderminster in 1757, have become famous, and of great notoriety, from the authority of GUYTON MORVEAU, the celebrated French chemist. But in introducing this chemical agent into the mines, I do not mean to withdraw a single sentiment which I have elsewhere uttered against *fumigation* for destroying contagion. The present subject is purely chemical, and chemical facts shall alone support my reasoning and practice here.

Had MORVEAU lived in a *coal district*, this essay of mine might have been anticipated.

His active revolutionary genius could not have with patience heard on the spot, of hydrogenous gas bursting into flame, and destroying thirty or forty men at a blast, without advertising to some measures that would either prevent or alleviate such occurrences in future. Though with FOURCROY, and other philosophers, he is a passive slave to the present tyrant of France, his otherwise enlightened spirit deserves this acknowledgment from a British physician. Sordid and selfish, indeed, must be the tenor of life in that professional man, who can traverse the acres of this neighbourhood for daily bread, and not do one kind action *gratis*; or sometimes cast a sympathizing look below to those industrious miners, who toil amidst darkness and dangers, whose labour gives the first spring to that commerce which is the best nursery of our seamen, and which brings back to the shores of the Tyne and the Wear, wealth of incalculable magnitude.

The late Dr. BROWNRIGG, of Whitehaven, a philosopher who devoted much of his studies to promote the arts in his neighbourhood, has written a small tract on the noxious airs of coal-mines. But he has not offered any plan beyond the common means for dislodging them. Indeed, at that time, Pneumatic Chemistry was in its infancy.

It has been long ago remarked, that, notwithstanding the folly and the absurdity of the *Alchemysts*, by the patience and ardour with which they prosecuted their inquiries, many collateral facts were established, and many valuable inventions and improvements in the working of metals, were the consequence of their labours. And it may with equal justice be said, during the reign of *Empiricism*, in which so many philosophers have stept forward with antidotes against contagion, that means almost certain are now known for annihilating those foul damps, or airs, which

arise in various departments of nature, the result of these experiments. To employ chemical agents in sick apartments, must at least be superfluous; because pure air, and soap and water, can be easily obtained to prevent the generation of unwholesome vapours. I object to their use in ships for the same reason; but these objections do not apply to the mine, as the depth from the surface renders ventilation imperfect. That it is not perfect, is confirmed from the frequent fatal accidents which happen.

An English chemist, I think it is Mr. WATT, in some of his communications to Dr. BEDDOES *on Factitious Airs*, was so convinced that the matter of contagion was some form of a gaseous fluid, that he tells his correspondent that he was afraid of stumbling upon the noxious gas that produced Typhus fever; and, under the impression of this dread of being infected, he stopped the farther profe-

cution of his experiments! MORVEAU, an adept in Pneumatic Chemistry, did not carry his enthusiasm so far. He asks, "What then
 " is the nature of those invisible *corpuscles*,
 " which, like organic beings, possess the power
 " of reproduction, and of assimilating to their
 " own essence every thing with which they
 " come into contact, and which seem to assume
 " *life*, but for the purpose of propagating
death?" Such is MORVEAU's creed on contagion; and if any meaning can be drawn from such a confession, he must have believed in an *animalcular* theory. But we must at the same time remember he was not a physician: yet he certainly ought, as a chemist, to have explained the nature of the new combinations formed by the muriatic acid vapours. This, like the author of the Nitrous Vapours, he withheld; probably by foreseeing that it would lead to inconsistency, and an open avowal of *quack-*

*ery.** That the substance of contagion is not *fire-damp*, the salubrity of mines and health of the pitmen sufficiently testify.

For the putrefaction of animal and vegetable matter, moisture in some form and quantity is absolutely necessary, and then only can we perceive by the smell those gaseous products evolved by this process. The difference between animal and vegetable putrefaction is, that, in the former, ammonical carbonat or volatile alkali is produced, although some vegetables likewise yield this substance, or rather the two ingredients which compose it. When speaking of the properties of hydrogen, or *fire-damp*, I mentioned the power it possessed of dissolving and suspending in it, carbon, sul-

* Both these authors of fumigation claimed credit to their respective *fumes*, in the fever which raged in Andalusia in 1800. But another fever appearing in the succeeding summer, and a third in the summer of 1804, extending to the garrison of Gibraltar, their *puffs* seem to be silenced. Like the epidemic of America, these fevers appeared at a regular period; and it is notorious, that they declined *only* from the cooling showers of Heaven, and the commencement of a cold season.

phur, phosphorus, and azote, when any of these happened to be presented to it; and from these articles it derives the nomination of *hydro-carbonat*, *hydro-sulphuret*, &c. Now these compound gases have all been examined chemically; and wherever we meet with foul smells from animal or vegetable putrefaction, they are invariably found to be derived from them. In order to destroy these smells, we have only to employ some of the stronger acids in a state of vapour, such as the acetic, nitrous, or oxygenated muriatic. These acid vapours seize the hydrogen or *fire-damp*, which suspends the others, and the fetid effluvia immediately disappear. And should the hydrogen be diffused in the atmosphere in a pure state, the acid fumes still arrest it to the point of saturation. The chemical theory of this union between the acid vapours and the *fire-damp*, is accounted for in this manner. In the expansile state of the acid gas, its oxy-

gen quits the radical or base of the acid, and attracts the hydrogen; water is thus recomposed; but as so great a quantity of heat, or caloric, is disengaged during the combination of the oxygen and hydrogen, the *water* is converted into *steam*, and cannot be condensed so as to be shown in its due form. This is the whole secret of destroying hydrogenous gas or *fire-damp*.

Chemists have not been minute in assigning their reasons, why the acid in a state of vapour is so apt to impart its oxygen to the hydrogen or *fire-damp*, as in this process. It probably depends on the repulsive power of the *caloric*, or matter of heat, which is necessary to expand the acid, and preserve it in a vapourific form; which, while it lessens the attraction between the oxygen and the base of the acid, must also, by multiplying the points of contact between the oxygen and hydrogen, facilitate their combination to form steam.

The oxygenated muriatic gas being a condition of the acid, where there is a quantity of oxygen beyond the point of saturation, must greatly favor the new combination, and accelerate the destruction of the *fire-damp*. This addition to the fumigation is the improvement of the late Mr. CRUIKSHANK, chemist to the Ordnance at Woolwich.

Any person who has the curiosity to try, may soon satisfy themselves of the oxygenated muriatic acid gas being a corrector of foul air impregnated with putrid exhalations, by using the ingredients as hereafter directed. This may be done over a foul kennel, privy, or any sink of corrupting matter. The fetor will disappear, till new vapours accumulate to renew the smell.

The following experiment on destroying *fire-damp* was made in a ship. A sloop of war, French built, when cruising, became very leaky, and required frequent pumping out.

She arrived at Spithead in warm weather, where, by lying in smooth water, she ceased to leak. But it was now observed, that her hold became very foul, and the bilge vapour extremely offensive in the decks, so as to blacken all the white paint. This vessel had no pipe for letting in water to sweeten the well, and the captain, having heard much of fumigation for destroying contagion, immediately set to work, and found the *fire-damp* disappear, and the smell and effect on the paint ceased from its use. This he repeated often, while the ship lay at Spithead; but when he went to sea, the water from the leaks made the hold so sweet, that it was not found necessary to continue the fumigation.*

Now this trial of the officer is just what ought to be done on a large scale in a coal-mine. And were the process for diffusing the muriatic acid vapours kept constantly up, *fire-damp* could never be dangerous; it would

* Med. Naut. vol. III,

be destroyed as soon as it was formed. The ingredients for the purpose being so very cheap, the largest mine could not consume one hundred pounds in the year by keeping the fumigation in constant use day and night.

Where *fire-damp* is confined or pent up in such a close situation as has recently happened in Hebburn colliery, it would be necessary to surround the spot with a number of vessels giving out the gas, and to open the door leading to it by slow degrees. The vessels might then be carried nearer and nearer, till the whole *fire-damp* was annihilated.

The utensils required for this business are small flat stone dishes, made thick, about two inches deep; and a glass funnel for pouring in the acid of vitriol. The ingredients are—common salt (it ought to be Bay salt), oxide of manganese, and concentrated acid of vitriol, which, in common language, is the strongest oil of vitriol.

Proportion for one fumigation.

	oz.	dr.	grs.
Take of common Bay salt	3	2	10
Fine powder of black manganese	0	5	17
Water	1	2	33
Strong sulphuric acid	1	7	50

After pounding the salt and manganese together, they may be put into the stone ware dish, and the water poured upon them; and afterwards the sulphuric acid, slowly, through a glass funnel. This quantity is sufficient for a space of 16 feet by 12; but the frequent employment must depend on the manner how the *fire-damp* is evolved.

I have mentioned Bay salt, which is marine salt obtained from sea-water by spontaneous evaporation, or the heat of the sun. Salt of this country is much inferior in quality, either for the present purpose, or for preserving meat; for much of its acid is exhaled during the preparation. Any person may learn the whole of this process in a few minutes.

The *choak-damp* of coal-mines, which is fatal to life when inhaled, and not to be perceived by smell or sight, is always found on the ground. It is a compound body, consisting, as has been said above, of carbon and oxygen; but their union is so strong, that it is in vain to think of effecting the separation by re-agents. The most practicable method for dislodging it is by water. Water, about the temperature of 40 of Fahrenheit, is found to dissolve equal parts of its bulk; but as the water of a deep pit is commonly above 50°, it will take up two-thirds of its bulk only. In order to effect this mixture with water, I would recommend the common fire-engine, such as is used in the case of fire. The workmen might for safety stand at a distance, and by directing the mouth of the tube to the spot where the *choak-damp* is known to lie, the water may be so diffused as to take up the whole. The water will then taste acidulous; and lights will

burn and animals breathe in the place whence the vapour was dislodged. That the diffusion of the water might be more speedy in dissolving the *choak-damp*, the tube might be fitted after the manner of a garden watering pot, so as to sprinkle and break the fluid into a shower.

This kind of air being speedily attracted by quick lime, by mixing that article in the water which is to be diffused would still more effectually dislodge the *choak-damp*; and in places where it happens to be collected in great quantity, such a mixture would be highly serviceable.

It ought to be remembered, whenever either *fire-damp* or *choak-damp* are detected in coal-pits, that there will be reason to fear a collection of the other near the spot, if not powerfully ventilated: for it is without doubt, that they are invariably generated by the same process, and at the same time.

I have been told, that particular places in these works are frequently deserted, on account of the foulness of their atmosphere rendering it dangerous for pitmen to approach them. If this be owing to either *fire* or *choak-damp*, or both, it does not seem beyond the power of art to annihilate them, and restore purity to the air, by which means property of immense value may be saved to the owners.*

Having thus endeavoured, in as familiar terms as the subject would admit, to explain

* In those situations and places where *fire* and *choak-damps* are lodged together, it would be advisable, first to use the plentiful diffusion of water, as it is known that water will also dissolve a large proportion of *fire-damp* along with *choak-damp*. It would then be proper to employ the fumigating materials, till the whole of the inflammable air is annihilated. The *choak-damp* being destructive to life, some animals, such as birds or mice, might be kept in small cages, and, for making experiments, so fixed to long poles, as to be held with safety at sufficient distance by a workman. If the animal die, no human being could then proceed without the utmost danger; and this might be considered as the test for using the engine to diffuse the water.

the production of *fire* and *choak-damps* in coal-mines, and to apply chemical facts for destroying them; with much pleasure I can observe, that the treatment of Burns, from these dreadful explosions, has lately been reduced to a science, by the spirited Essays of Dr. EDWARD KENTISH. The invention of the *stimulant* practice, it is said, belongs to Mr. HUNTLY, surgeon in this neighbourhood; but that will not detract from the well-earned reputation of Dr. KENTISH, who has explained the doctrine on the just principles of a correct PATHOLOGY, and so connected it with MEDICAL PHILOSOPHY, as to rescue this department of *Surgery* from *Primæval Empiricism*. The workmen in coal-mines have reason to bless his labours, and posterity will receive his improvement with gratitude and thanks.

P. S. Nov. 1. This essay was originally intended for publication in a Newcastle newf-

paper; but, from the explanation of the subject, it has necessarily extended to a greater length than was at first expected, which made the author print it in the present form.—The author will be very happy to give any information in his power, to such as may wish for it, on the subjects here treated of.

FINIS.

[From the preſs of J. Mitchell, Newcastle.]

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